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DEFENCE RESEARCH GROUP

PANEL 11 ON INFORMATION PROCESSING TECHNOLOGY

Executive Summary of the Technical Proceedings on
Military Information System Engineering

1.   This is the Executive Summary of the Technical Proceedings of the
Symposium on Military Information System Engineering. The full report has been
distributed under reference AC/243(Panel 11)TP/1 dated 27 December 1991.

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EXECUTIVE SUMMARY

0.1 Summary of the Symposium

i.   The symposium provided a forum for information exchange and discussion of current research in information processing technology and its application to the engineering of military information systems.

ii.   The objectives were:

(a) To assess the problems of engineering information processing systems for military use

(b) To identify emerging technologies and techniques for system engineering and evaluate the benefits offered

(c) To determine the research needed to facilitate the introduction and application of beneficial techniques to the engineering of future military systems.

iii.   The following summary outlines the topics considered in the presentations and the major points of the discussions. Four sessions were held on the topics of:

(a) Engineering for the System Life-Cycle

(b) Knowledge-Based Systems

(c) Software Technology

(d) C3I Systems Development

0.2 Engineering for the System Life-Cycle

iv.   Six papers were presented covering prototyping, software evolution, object-oriented and transformational techniques for system specification, formal methods and the spiral model for life-cycle system development. Some of the questions addressed were (1) the purpose, potential benefits and problems of prototyping and (2) the identification of various models for system development, and their suitability and application.

v.   The following observations were made. There is more than one model for life-cycle systems development. They range from the traditional waterfall model, which is understood from a conceptual and contracting point of view but which is not effective for systems addressing vague or evolving requirements, through models which involve prototyping to the spiral model which assumes a number of iterations and can develop at each iteration a system that contains subsystems at differing levels of abstraction. Although spiral-type life-cycle models appear most attractive for military systems, there has been little practical experience with them and there needs to be a cultural change to allow them to be addressed by the procurement agencies and to be managed effectively.

vi.   The purpose of prototyping is to clarify requirements, to solidify specifications, and to give an early "look and feel" for the system users. This leads to significant user involvement in the early stages and better user understanding and acceptance of the developed system. However it can lead to design decisions being made too early in the development cycle. There can be a perception that the prototype is the real system and that further (costly) engineering need not take place. This is a tendency that should be resisted as prototyping tends to concentrate on the mainstream requirements rather than the exceptions.

vii.   The session identified formal methods and object-oriented paradigms as emerging technologies addressing the requirements and specification phases. Formal methods give the potential for error-free transformations from system specification to implementation. The object-oriented methods support rapid prototyping.

0.3   Knowledge-based Systems

viii.   Two papers focused on the use of Artificial Intelligence techniques for the automation of software development, and the quality control of expert systems for operational use.

ix.   The goal of automating software development from an initial (formal) specification into executable code is ambitious and long-term. For data handling, the research addresses data type design rather than algorithms. Real-time issues are not yet considered.

x.   Validation of expert systems intended for operational use is essential. Traditional development and quality control models do not map well on to expert systems. Reliability and maintainability of the knowledge base are recognized as the principal quality criteria.

xi.   Future operational use of knowledge-based systems should not be restricted to stand-alone sub-systems. They could offer a higher level of help in decision making within command and control systems. This raises questions such as (1) how to connect a knowledge base to the rest of the system (2) how to identify and bound the necessary knowledge and (3) how to collect the knowledge that exists.

0.4   Software Technology

xii.   Three papers identified promising technologies for the improved development of software systems: a universal intermediate language (TDF) as an architecture-independent and programming language-independent format for program; the development language DEVA, aimed at the formal development of software objects which would be "correct by construction"; and some aspects of the ARCADIA research programme.

xiii.   The potential impact of these technologies was described. A universal intermediate language is an approach to software distribution and portability. The introduction of an ANDF (Architecture Neutral Distribution Format) is expected to increase software re-use, encouraging the sale of software components which would all be distributed in ANDF for installation on a variety of computer architectures.

xiv.   The use of formal methods was seen as conferring advantages in obtaining correct programs and to be fruitful in the context of software re-use as a means of solving sets of similar problems. Potential problems are its scalability for large systems and possible difficulties of understanding.

xv.   The ARCADIA approach attempts to break down the distinction between programming language facilities and database facilities by providing strong typing integrated with persistent data. Discussion included comparison with the PCTE and CAIS interface specifications. Both PCTE and CAIS use a separate database management system. These systems were observed to be based on 1970's research, whereas persistent systems were aimed at the next generation.

0.5   C3I Systems Development

xvi.   Four papers ranged from the conceptual to the experimental. An experimental implementation was reported of a general architecture for a distributed command and control information system using the ISO/OSI Reference Model, the Ada language and commercial off-the-shelf software (COTS). This highlighted the effort still needed to adapt and integrate COTS with security components and specific applications such as expert system components.

xvii.   A paper on the development approach for C3I illustrated the
benefits offered by object oriented languages in meeting characteristics of
C3I systems such as interoperability, security, integrity and testability, and
the need for the system to evolve to be able to handle changes.

xviii.   A case study of the development of Army C3I systems described
activities over 20 years. Extensive system modelling was carried out to
define the hardware and software architectures with respect to redundancy,
performance, survivability and functionality. The subsequent paper also
developed the theme of survivability. Survivability may be achieved in the
most cost-effective way through replication of function and dispersion.
Experiments looked at multi-media communications capability, the evaluation
of re-connection strategies and the use of advanced technologies for creating
a strategy planning system in a highly stressed environment.

xix.   The discussion again emphasised that the role of the user during
system development is essential. The development method must be chosen
accordingly and prototyping seems a promising approach. Military users are
conservative in terms of technology, so high level quality prototypes are
essential for acceptance.

0.6   Main Conclusions

xx.   Several emerging technologies were identified as having potential
benefit for future military systems. Various technical problem areas were
agreed to need continuing research. In addition, the discussions identified
significant problems concerned with the mapping of new system development
methods and life-cycle models to procurement practices.

xxi.   Emerging technologies include formal methods, prototyping, object-
oriented programming, knowledge-based systems, persistent data systems and
techniques for software portability. Many different and promising paradigms
are being used. However, the integration of the different development
paradigms can cause problems, particularly in the approach to system
integration. Formal methods are currently immature but will become an
important tool in the longer term. This was identified as one of the topics
for future research activities.

xxii.   Further work is needed to define the role of prototyping and its
relation to the system development model. An important element for study is
the means of transition from prototype to engineered operational system. The
infrastructure for operational systems seems less well developed than that

currently being applied within the prototyping environments. To ease the transition further work should identify improvements for the operational infrastructure and how they might be achieved.

xxiii.   The development of C3I systems requires specific approaches to solve problems such as the integration process, the use of commercially available hardware and/or software, the re-usability of software and more specifically military issues such as security, interoperability and survivability. This type of system is very complex and requires a large variety of engineering disciplines. Research and experimentation has shown the value of an incremental and evolutionary development process including prototyping. The issues raised by this are not only technical but concern the adaptation of procurement policies to the emerging development technology. Such issues were not considered as direct research problems.

0.7   Major Recommendations

xxiv.   The symposium identified several areas to be considered for future activities of Panel 11, including Formal Methods, Software re-usability, portability, and interoperability, the use of Commercial off-the-shelf software and Knowledge Engineering in C3I.

xxv.   The symposium discussions found that it was difficult to evaluate the benefits offered by emerging technology in the context of current procurement practice. The involvement of the military sponsor and the future operational user from an early stage is essential in incremental and iterative development. No recognized mechanisms exist to ensure this involvement.

xxvi.   Thus, in considering the impact of emerging technology the problems are not entirely technical. Many are connected with the acquisition culture in defence which is strongly connected to a waterfall model of systems development. Current procurement practice was felt to legislate against the benefits expected from incremental and evolutionary development.

xxvii.   There is an urgent need for a transition strategy, including consideration of changed procurement practices, in order to allow full use of beneficial emerging technology in the engineering of future military information systems.

0.8   Military Implications

xxviii.   Military operations place increasing reliance on the use of software based systems for military operations. Systems in which software has a critical part range from embedded weapons systems to large distributed C3I.

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The characteristics required of military C3I systems include security, reliability, interoperability and survivability. This implies certain properties of the system architecture such as distribution and reconfigurability. System development is carried out against a background of rapidly developing commercial hardware technology offering considerable price and performance benefits. However, commercial developments in systems engineering have not kept pace with this hardware technology improvement and do not adequately address specific military requirements.

xxix.   System procurement practices allowing for incremental and evolutionary development would bring significant benefit. These methods help to clarify requirements. They allow the incorporation of commercial off-the-shelf software in appropriate subsystems. They allow utilization of relevant standards including emerging Open Systems. Increasing re-use of software and the ability to take timely advantage of commercial investment will be essential for the cost-effective development and interoperability of future military systems.

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